International Journal of Scientific & Engineering Research Volume 11, Issue 1, January-2020
ISSN 2229-5518

Automatic Feature Extraction from ECG Signal

Md. Anisur Rahman [1], Md. Alamgir [2]
Lecturer, Department of CSE, Z.H. Sikder University of Science & Technology, Shariatpur, Bangladesh[1, 2]

Abstract— ECG describes the electrical activity of the heart and represents the graphical wave through which a physiologist can identify diseases of the heart. ECG consists of five waves such as P, Q, R, S and T wave. An ECG signal contaminated with noise. The noise is removed by digital band pass filter. There are many algorithms for calculating heart rate. Pan-Tomkins algorithm is one of them which gives more accuracy to heart rate than any other algorithms. Pan-Tomkins algorithm has been used to identify the R peak. At first low pass filter has been used to remove the high frequency. Then high pass filter has been used to remove the low frequency. The derivative filter, squaring function, moving window function and threshold method have also been used to identify it. Finally R peak is detected. After that heart rate is being calculated from R-R interval emitted from the signal. Average amplitude of R-wave and total number of R-peak are being calculated from the signal.

Keywords: Electrocardiograph (ECG), ECG Data, Pan-Tompkins Algorithm (PTA), R peak, Heart rate.

———————————— ◆ ————————————

Introduction

ECG is usually a recording of an electrical signal obtains from the body surface and represents the sum of action potentials from the heart cells. Electrical activity of the heart is shown by the changes of electrical voltage on the body surface. Human body is conductive because it consists of a lot of electrical live ions. The physical activity of the heart is connected with its electrical activity. Therefore, heart beats that repeat periodically. The time axis usually uses the order of milliseconds, as the potential axis generally uses the order of millivolts[1].

Willem Einthoven (21 May 1860 – 29 September 1927) was a Dutch doctor and physiologist. He invented the first practical electrocardiogram (ECG) in 1903 and achieved the novel prize in medicine in 1924 for it [2]. Heart Rate Variability (HRV) can be determined from ECG signal.

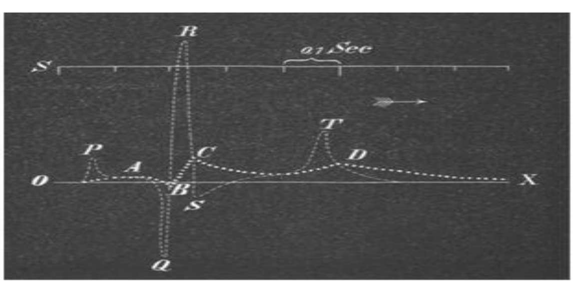

Fig. 1: Two Superimposed ECGs [3].

Uncorrected curve is labeled ABCD. This tracing was made with processed Lippmann capillary electrometer. The other curve was mathematically solved by Einthoven to permit for inertia and friction in the capillary tube. He selected the letters PQRST for the adjusted curve dependent on mathematical history of labeling successive point on a curve.

ECG means electrocardiogram. All the electrical activity of the heart representing in graph this process is called ECG. ECG signal reflects the electric activities of a heart muscles. The ECG pattern consists of a repeated wave sequence of P, QRS and T-wave related to each beat. The first deflection, termed the P-wave has been created for the depolarization of the atria. The large QRS-complex has been created for the depolarization the ventricles [3]. Myocardial ischemia is caused by a lack of sufficient blood flow to the contractile cells and many leads to myocardial information with its severe sequel of heart failure, arrhythmias and death [4].

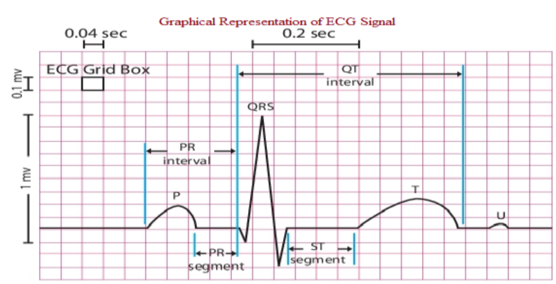

Fig. 2: Typical ECG Signal.

There are two basic kinds of arrhythmias.

Bradycardia: Bradycardia is a slow heart rate when the heart rate is too slow that means less than 60 beats per minute.

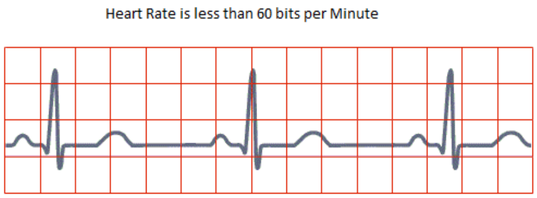

Fig. 3: Bradycardia.

Tachycardia: Tachycardia is a fast heart rate when the heart rate is too fast that is more than 100 beats per minute [5].

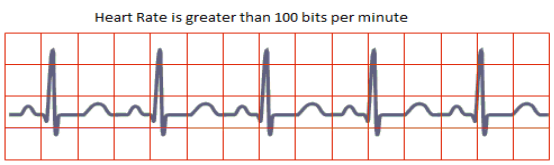

Fig. 4: Tachycardia.

System Model

In order to extract information from the ECG signal, the raw ECG signal should be processed. An ECG signal contaminated with noise .The noises have been removed by digital band pass filter.We implement R-peak detection algorithm by using Pan-Tomkins algorithm. First of all there is a band-pass filter which is consisted of low pass-filter and high-pass filter. It can remove the noise. After that derivative has been used to get the slope. Then a squaring function has been used to get the positive point and then the signal is passed through the moving window integrator. After that threshold methodhas been done to locate the R-peaks [6].

Data Acquisition

A set of ECG records obtained from the data file [5].Then we have stored it in a text file.Its sampling rate 100Hz. It is contaminated with noise. It can be used for representing ECG signal. We can extract feature from the signal.

Pan-Tompkins algorithm is used for higher accuracy for various beats than other traditional real-time methods. Various steps of Pan-Tompkins algorithm is shown below:

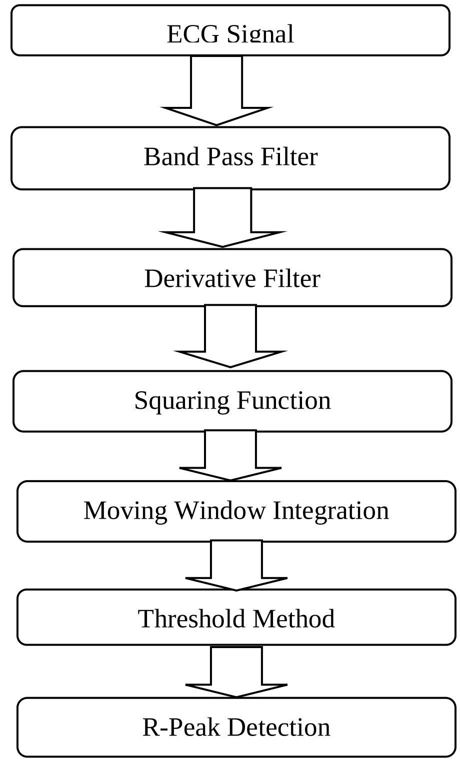

Fig. 5: Pan-Tomkins Algorithm for R-Peak detection

The signal length is 6000 samples, sampling rate is 100Hz. The following input figure (Fig. 6) for 1000 samples that have been plottedas:

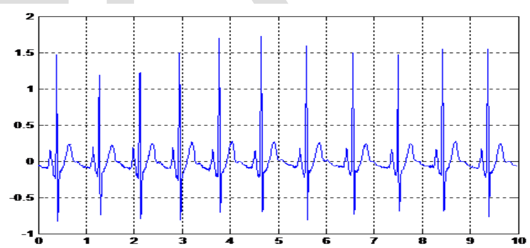

Fig. 6: Raw ECG Signal.

In Fig. 7 we have got maximum value at most 1.We have found the following figure:

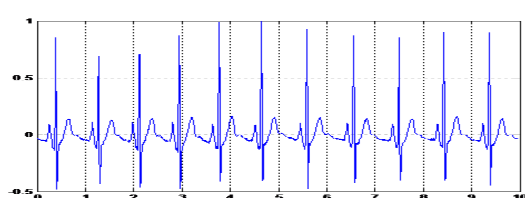

Fig. 7: After Normalization of ECG Signal.

Band pass Filter

This band pass filter is constructed by low pass filter and high pass filter in cascade. The band pass filter can be used to reduce the baseline wander interference, muscle noise and T-wave interference [7].

Low-pass Filter

The transfer for 2nd order low pass filter is given by:

$$H(x) = \frac{1-2x^{-6}+x^{-12}}{1-2x^{-1}+x^{-2}}$$

And the functional equation for low pass filter is:

y[n]=2y[n-1]- y[n-2]+x[n]-2x[n-6]+x[n-12]

In Fig. 8 for low-pass filter b, a and zeros array of function have been used by

h=filter(b, a, [1 zeros(1, 12)])

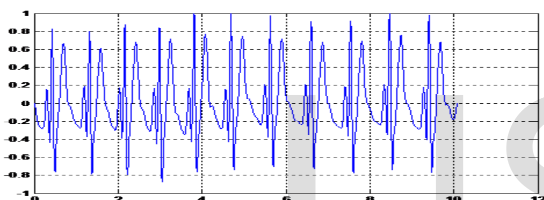

Fig. 8: Low-Pass Filter after Normalization of ECG Signal.

High-pass Filter

The transfer for 2nd order low pass filter is given by:

$$H(x) = \frac{-1+32x^{-16}+x^{-32}}{1+x^{-1}}$$

In Fig. 9 for high-pass filter b, a and zeros array of function have been used by h1=filter(b,a,[1 zeros(1,32)]).

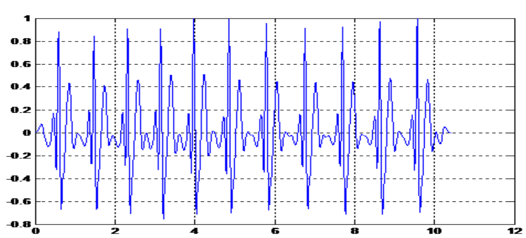

Fig. 9: High-Pass Filter after Normalization of ECG Signal.

Derivative Filter

After filtering, the filtered signal is derivative i.e. differentiated is used to get the slope information of the input signal.

In this we have been used five –point derivative with the transfer function

$$H(x)=(-x^{-2}-2x^{-1}+2x^{1}+x^{2})\frac{1}{8T}$$

In Fig. 10 for differentiator, differential parameter has used h2. We have used convolution function with h2 and the output of normalization of high-pass filter (Fig. 9). In this process delay are 2 samples. Calculate the absolute value of the convolution result and have found the maximum value from convolution result.

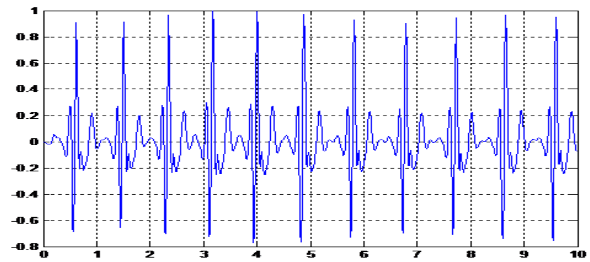

Fig. 10: Differentiator after Normalization of ECG Signal.

Squaring Function

Squaring function can be used to get positive values from the negative or positive values.It also used to fraction value into smaller value and integer value into bigger.After differentiation, point by point squaring is done on the signal. The equation of this operation is

$$Y(nT)= [x(nT)]^2$$

In Fig. 11 for squaring function, square the output of the normalization from the differentiator (Fig. 10).

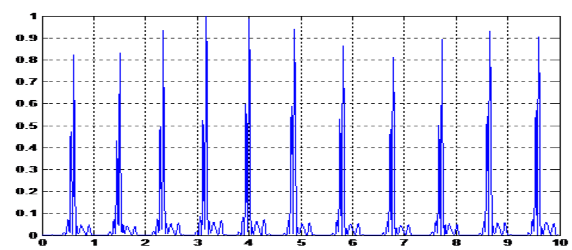

Fig. 11: Squaring Function after Normalization of ECG Signal.

Moving Window Integration

The moving filter smoothing the data by replacing each data point with the given number of neighbors. The objective of moving window integration is to obtain wave form feature information in addition to the slope of the R wave. It can be calculated from

$$Y(nT)=\frac{[x(nT-(N-1)T)+x(nT-(N-2)T)+ \ldots\ldots x(nT)]}{N}$$

Where N is the number of samples in the width ofthe integrationwindow.In Fig. 12 for moving window integratorones array of function h3 is used. We have used convolution function with the h3 and output of normalization of squaring function (Fig. 11).

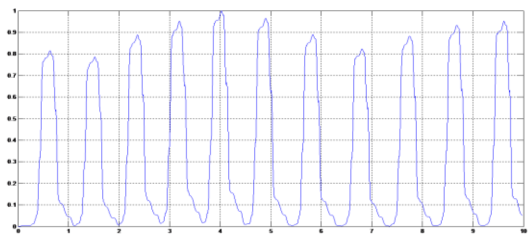

Fig. 12: Moving Window Integrator after Normalization of ECG Signal.

Threshold Method

After moving window integration, threshold method is used to find the R-peak. A maximum level is set which helps in detecting R-peak.QRS complex is also called fiducial marks.

In Fig. 13 we have calculated the threshold first we have calculated maximum value from the normalization of the moving window integrator (Fig. 12).

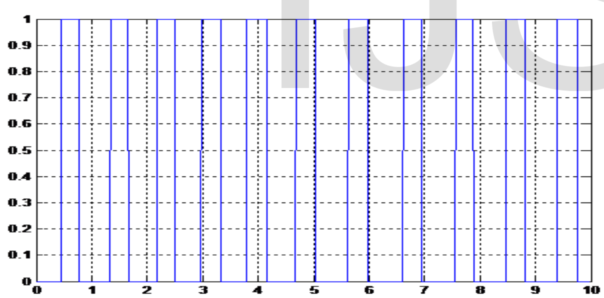

Fig. 13: Output of Pulse Detection.

Heart Rate can be calculated from the above formula:

In Fig. 14 R-peak has been detected. Then we have calculated R-R interval. R-R interval has been calculated between two R-peaks and average R-R interval has calculated from the total number of R-peak.

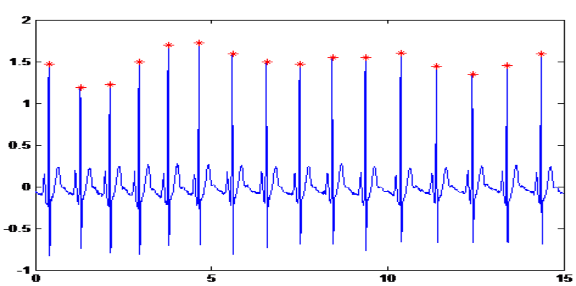

Fig. 14: R-peak Detection.

Heart Rate= $\frac{Sampling\ Rate*60}{R-R\ Interval}$bpm

Result:

For the samples of 1000

Total Number of R- Peak: 11.

Average R Wave Amplitude: 1.4950.

Heart Rate is: 64.5161 bits/min.
Decision: The Subject is suffering from Bradycardia.

Conclusion and Future Work

ECG is an important tool in the diagnosis and analysis of the heart activity. Heart rate can be calculated from the ECG signal. Physiologist can measure functional status of the heart from ECG signal.We have proposed Pan-Tomkins algorithm for developing a system for feature extraction from ECG signal. In this research paper, to classify the ECG heart rate from the data file using Pan-Tomkins algorithm. The Pan-Tomkins algorithm is signal dependent in the sense of fidutialpoints detection. The threshold used for R-peak detection. After R-peak detection, average R-R interval has calculated and heart rate has been calculated. After calculating heart rate we can identify heart arrhythmias. The R-peak identified essential for classification, analysis and arrhythmia detection including Tachycardia and Bradycardia. The Pan-Tomkins algorithm gives more accuracy value than any other algorithms. In this thesis paper, we have been used only one ECG data file. In future we will use multiple ECG data files. We have been calculated average amplitude of R-wave, total number of R-peak, R-R interval and heart rate. We will try to calculate P-wave, P-R interval, ST segment.

REFERENCES

1. AutorPrace, VedouciPrace and DoktorskaPrace,"Methods For Detection And Classification In Ecg Analysis".
2. https://ecglibrary.com/ecghist.html.
3. MajdAlGhatrif, Joseph Lindsay, "Methods For Detection And Classification In Ecg Analysis", J Community Hosp Intern Med Perspect. 2012; 2(1): 10.3402/jchimp.v2i1.14383,2012 Apr 30.
4. S. S. Mehta, IAENG Member and N. S. Lingayat, IAENG Member, "Detection of P and T-waves in Electrocardiogram", Proceedings of the World Congress on Engineering and Computer Science 2008,ISBN: 978-988-98671-0-2.

5. http://eleceng.dit.ie/dorran/matlab/ecg.txt.

6. KritikaBawa,PoojaSabherwal, "R-Peak Detection by Modified Pan-Tompkins algorithm" International Journal of Advancements in Research & Technology, Volume 3, Issue5 , May-2014 30 ISSN 2278-7763.
7. JiapuPan and Willis J.Tompkins, a real-time QRS detection algorithm, IEEEtransactions on biomedical engineering, vol. bme-32, no. 3,march1985.

BIOGRAPHIES

Md. Anisur Rahman[1] received his B.Sc. & M.Sc. degree in Computer Science & Engineering from the department of Computer Science and Engineerig of Islamic University, Kushtia, Bangladesh. Now, he is a Lecturer in the department of Computer Science & Engineering, Z.H. Sikder Science & Technology University, Shariatpur, Bangladesh. His research interest includes Biomedical Engineering, Signal Processing, Data Security, Antenna and Big Data.

Md. Alamgir[2] received his B.Sc. & M.Sc. degree in Computer Science & Engineering from the department of Computer Science and Engineerig of Islamic University, Kushtia, Bangladesh. Now, he is a Lecturer in the department of Computer Science & Engineering, Z.H. Sikder Science & Technology University, Shariatpur, Bangladesh. His research interest includes Signal Processing, Water Marking Technology, Data Security, Antenna and Big Data.